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Native Plant Population Structure Under Native- and Alien-Dominated Canopies in Makua Valley, Oahu

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Abstract. This study examined native species population structure in a managed reserve composed of adjacent native- and alien-dominated stands. Total and juvenile species diversity was higher in native stands than in alien stands. However, juvenile diversity was lower than total diversity. Alien ground cover was higher than native ground cover in native stands indicating invasion. Alien species had more cover per species at all levels. Excluding *Alyxia oliviformis*, there were fewer native juveniles than alien juveniles in both native and alien stands. *Schinus terebinthifolius* (native stands) and *Psidium cattleianum* (alien stands) were the only alien species recruiting. Five native species were recruiting in native stands but only two native were recruiting in alien stands. Of these, only one had a stable population structure. Eleven native species showed no recruitment at all. These data suggest that native populations may be in decline, and that impediments to recruitment need further investigation.

Globally, biological invasion threatens the integrity of native habitats. In the United States, 41% of all endangered plant species are endemic to Hawaii (c.f. USFWS 1998). OF the 2034 species in the current Hawaiian flora, 891 are alien (c.f. Vitousek et al. 1997). These aliens pose threats to the endemic species in several ways. Plants reproducing via clonal growth is a major concern because they can outpace the reproduction of natives (Huenneke

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1990). Several alien plants secrete allelopathic substances (Smith 1985 and sources therein). They can also act as hosts for pests and diseases that spread to natives (Smith 1985). Alien animals also have destructive impacts on native species, including herbivory and habitat disturbance (Smith 1985). This disturbance can encourage the establishment of alien plants (Aplet et al. 1991). Alien animals also act as dispersers of alien plants (Panetta and McKee 1997; Huenneke 1990). All of these detrimental impacts may inhibit the regeneration of native species and lower overall species diversity (Harrington and Ewel 1997; Vitousek et al. 1997).

Population structure studies can address regeneration. The age distribution of a population can illustrate whether regeneration is occurring, and can also predict the likelihood of the population's persistence. In a stable population, for example, juveniles should be more numerous than adults. Stage classes are often substituted for age classes, and for woody species, size or height may be equated with stage (Barbour et al. 1987).

Our study examined the population structure of native plants in the Kahanahaiki Management Unit, located in Makua Military Reserve, on the West coast of Oahu. Kahanahaiki is a 110-acre management unit whose elevation ranges from 1500 to 2300 feet. It is a diverse mesic forest, and it contains ten endangered plant species, one endangered snail, and one proposed endangered bird species (RCUH 1998).

The use of Makua for Army maneuvers and live-artillery training creates hazards for the natural habitat. These hazards include munitions fires and the spread of alien plants. In order to minimize and mitigate for these impacts, natural resource management began in 1995. The management includes control of alien animals and plants, revegetation, and monitoring. In January 1997, a fence surrounding 90 acres was completed, excluding feral pigs (*Sus scrofa*) and goats (*Capra hircus*) from Kahanahaiki. Carnivorous snails (*Euglandina rosea*) and rats (*Rattus* spp.) are controlled with exclosures and poison bait. Common alien trees in Kahanahaiki are Christmas berry, *Schinus terebinthifolius* and strawberry guava, *Psidium cattleianum*. Aliens in the ground cover include the invasive grasses *Oplismenus hirtellus* and *Paspalum conjugatum*, and the invasive fern *Blechnum occidentale* (RCUH 1998).

Currently, Kahanahaiki consists of adjacent native- and alien-dominated stands. These adjacent stands are apparently quite discrete, but alien species may be invading native-dominated stands. The goal of the current management regime is to prevent alien invasion. This study investigated whether invasion is still underway, and whether native stands are regenerating.

This study focused on indices of species diversity, invasion, and regeneration. The hypotheses about diversity were: 1) Species diversity is greater in native stands than in alien stands; 2) Species diversity among juveniles is greater in native stands than in alien stands. The hypotheses addressing invasion were: 3) The amount of alien ground cover is higher than native ground cover; 4) The amount of alien cover per species is higher than native cover per species. The regeneration hypothesis was: 5) The proportion of native juveniles is higher than alien juveniles in native stands, and conversely, the proportion of alien juveniles is higher in alien stands. Descriptions of regeneration included 1) Alien species recruitment; 2) Native species recruitment in native areas and in alien areas.

Materials and Methods

Three sites were selected within the fenced region of Kahanahaiki. Sites were adjacent native- and alien- dominated stands within

areas with similar slope and aspect. Native-dominated stands were stands with 275% native canopy cover. Alien-dominated stands were stands with ≥75% native canopy cover. Within each native/alien stand two 5m by 5m plots were randomly placed. A total of 6 native plots paired with 6 alien plots were measured.

Each plot was divided into size (height) classes. These classes were ground level (<10 cm), mid-level (10 cm - 2 m), and canopy level (>2 m). Woody individuals were characterized as juvenile, sapling, or adult, based on their size class. Non-woody species were classified only by cover. The sapling category was not appropriate for woody vines; these individuals were characterized as juvenile (<20 cm) or adult (>20 cm).

Individuals of each species in each size class were counted, and estimations were made of percent cover of each species at each level. Total native and alien cover was also estimated at each level. Cover was equated with foliage.

Data was analyzed by averaging the two plots within each stand, and pairing stands within sites. Statistical analysis of species diversity, alien ground cover, and cover per species used one-sided paired t-tests.

Results and Discussion

Species diversity

Species diversity was calculated by counting the total number of species in each plot, averaging the two plots in each stand, and comparing paired stands within sites. There was a trend of higher total species diversity in native stands than in alien stands (P=0.059), though this was less true for site 3 (Fig. 1). There was also a trend of higher species diversity among juveniles in native stands than in alien stands (P=0.076, Fig. 2).

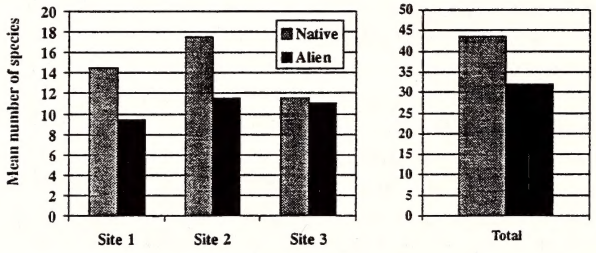

Fig. 1. Mean total species diversity at each siténd sum of the means. Hypothesis: Mean total species diversity is higher in native stands than in alien stands. (One-sided paired *t*-test. P=0.0059).

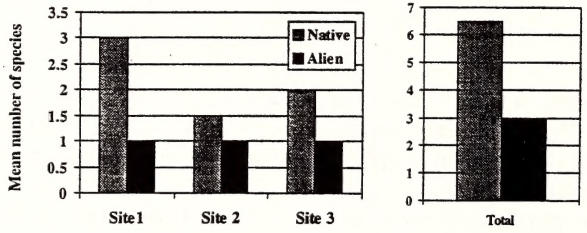

Fig. 2. Mean juvenile species diversity at each site, and sum of the means. Hypothesis: Mean juvenile species diversity is higher in native stands than in alien stands. (One-sided paired *t*-test. P=0.076).

The sum of the mean total diversity was 43. To compare this to the juvenile diversity, the non-woody species were subtracted. The sum of the mean total diversity for woody species was 29.5. The sum of the mean juvenile diversity was only 6.5, much lower than the total diversity. If the current species diversity of juveniles is an accurate predictor of future canopy diversity, it appears that canopy diversity will decrease drastically.

Invasion

Alien ground cover in native and alien stands was compared between sites. In native stands, alien ground cover was significantly higher (P = 0.001) than native ground cover (Fig. 3). Invasive grasses *Oplismenus hirtellus* and *Paspalum conjugatum*, which were found in all native stands, were the primary contributors to this cover. The hypothesis that native plots were being invaded at the ground level was supported. Alien ground cover was not higher in alien stands (P = 0.60, Fig. 3). The fact that these stands were weeded should be taken into consideration. While all sites received some weeding over the past two years, managers were unable to specify how much had occurred in any specific plot.

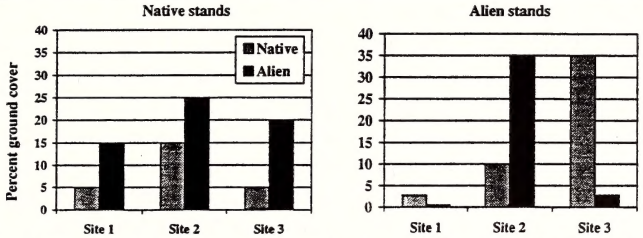

Fig. 3. Percent alien ground cover in native and alien stands. Hypothesis: Alien ground cover was higher. (One-sided paired *t*-test. Native stands: P:0.001; Alien stands: P:0.60)

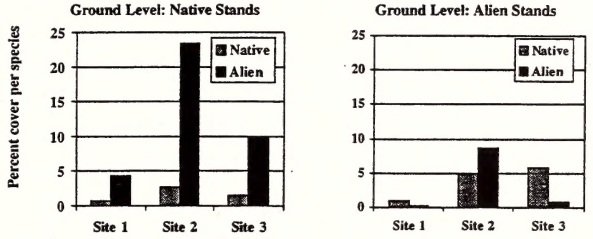

Fig. 4. Percent ground cover per species in native and alien stands. Hypothesis: Alien ground cover per species was higher. (One-sided paired *t*-test. Native stands: P=0.81; Alien stands: P=0.58.)

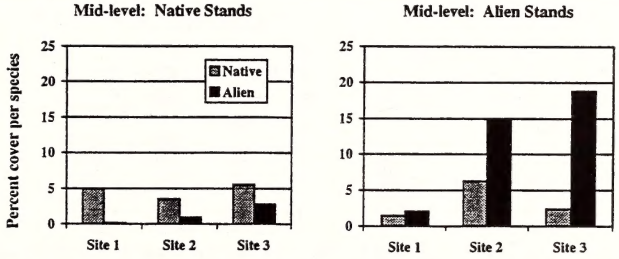

Fig. 5. Percent mid-level cover per species in native and alien stands. Hypothesis: Alien cover was higher. (One-sided paired *t*-test. Native stands: P=0.98; Alien stands: P=0.10.)

The quantity of cover each species occupied was also calculated for each level. Cover per species was determined for alien species by dividing the percent alien cover by the number of alien species. The same was done for native species. Following the prediction that species diversity would decline in alien-dominated areas, we also predicted that alien species would occupy more space per species. The alien ground cover per species was higher than native ground cover per species in native stands (P=0.081), but not in alien stands (P=0.58, Fig. 4). At the mid-level, in native stands, the alien ground cover per species was not higher than the native cover per species (P=0.98); in fact, the reverse was true (Fig. 5). At the mid-level in alien stands, alien cover per species was generally higher (P=0.1, Fig. 5). At the canopy level, alien ground cover per species was higher in native stands (P=0.036), and was substantially higher in alien stands (P=0.019, Fig. 6). It seemed that where alien cover was not higher than native cover, the alien cover per species was also low. This was true in alien stands at the ground level, and in native stands at the mid-level, where alien cover was not higher (P=0.60, P=0.85). When alien cover was high, alien cover per species was high, and so in these areas alien cover consisted of a few species occupying the majority of the space.

Regeneration

In both native and alien stands, there was a higher percentage of native juveniles than alien juveniles (Table 1). This contradicted our hypothesis that alien species would be more prevalent in alien areas, but was a promising finding for regeneration of native stands. However, since this analysis used numbers of individuals, rather than numbers of species, it was subject to skew from species with high numbers of individuals. One such species was *Alyxia oliviformis*, which was recruiting in much higher numbers than the other native juveniles. There were 594 *Alyxia* juveniles in all plots, as opposed to the next most common native juvenile, *Pisonia sandwicensis*, of which there were only 25. Without *Alyxia*, the proportions were reversed. There were more alien juveniles than native juveniles in both native and alien stands (Table 1). Alien juveniles are invading native stands.

Table 1. Percentages of native and alien juveniles in native and alien plots. (Values for stands when *Alyxia oliviformis* is excluded from calculations are listed parenthetically).

	% Native Species	% Alien Species	Total
Native Stands	90.2 (45.0)	9.8 (55.0)	100
Alien Stands	72.2 (14.0)	27.8 (86.0)	100

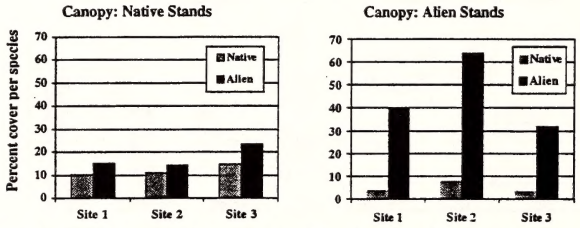

Fig. 6. Cover per species in native and alien stands. Hypothesis: Alien cover per species was higher. (One-sided paired *t*-test. Native stands: P=0.036; Alien stands: P:0.019).

Table 2. Native species that are recruiting in native stands. Only juvenile and adult stages were scored for *Alyxia oliviformis*, as it is a woody vine. Juv. = juvenile plants; Sap. = saplings; Ad. = adult plants.

Species	Juv.	Sap.	Ad.
Native Stands			
Alyxia oliviformis	504	na	105
Pisonia sandwicensis	25	57	40
Diospyros sandwicensis	14	6	47
Diospyros hillebrandii	8	9	32
Senna gaudichaudii	1	0	0
Sydrax odoratum	0	11	28
Alien Stands			
Alyxiz oliviformis	504	na	105
Sydrax odoratum	6	11	12

Table 3. Native species that are not recruiting in any stands. Asterisks indicate species of particular concern due to much higher numbers of adults relative to juveniles. Only juvenile and adult stages were scored for Coprosma foliosa, as it is a woody vine. Juv.=juvenile plants; Sap.=saplings; Ad.=adult plants.

Species	Juv.	Sap.	Ad.
*Nestegis sandwicensis**	0	1	13
*Hedyotis terminalis**	1	1	13
Antidesma platyphyllum	0	1	5
Metrosideros polymorpha	0	0	4
Coprosma foliosa	0	na	3
Hibiscus arnottianus	0	4	0
Chamaesyce multiformis	0	3	0
Myrsine lessertiana	0	0	2
Psychotria hathewayi	0	0	2
Morinda trimera	0	0	1
Pouteria sandwicensis	0	1	0
Melicope peduncularis	0	0	1

Recruitment

Alien recruitment was limited to two species, *Psidium cattleianum* and *Schinus terebinthifolius*. This was to be expected, since either or both of these species were present in every plot, whereas other alien trees were only present in one plot each. When native and alien stands were compared, differences between the two species' recruitment became apparent. *P. cattleianum* recruits almost entirely in alien stands, and *S. terebinthifolius* recruits exclusively in native stands (**Fig.** 7). This may arise from some kind of competitive interaction between the two species. The result is that *S. terebinthifolius* appears to be invading native stands in this area more than *P. cattleianum*. Theoretically, native species would be most likely to recruit in native stands, where the habitat is least disturbed by alien species. There were higher numbers of native species recruiting in native stands (5 species) than in alien stands (2 species, Table 2). However, these species had very low numbers of juveniles, indicating that their populations may not be stable (Table 2). Instead, for 3 out of the 6 species, adult numbers are higher than juvenile numbers; these populations may be in decline.

Knowing which natives recruit in alien areas can help predict which species will survive under the alien canopy that dominates much of Kahanahaiki. This knowledge can also help predict which species would be good

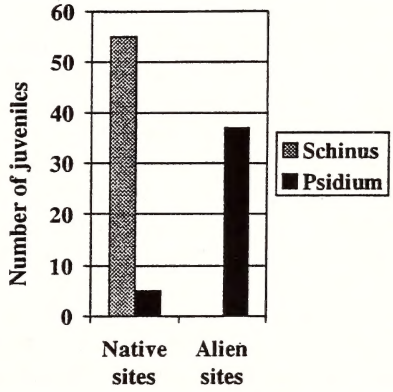

Fig. 7. Numbers of *Schinus terebinthifolius* and *Psidium cattleianum* juveniles in native and alien plants.

candidates for outplanting beneath alien canopy. The only two species recruiting in alien areas were *Sydrax odoratum* and *Alyxia oliviformis* (Table 2). Surprisingly, *S. odoratum* was not recruiting in any of the native plots (Table 2). *S. odoratum* is a native canopy dominant, and since there were high numbers of adults in native stands, there should have been seedlings in native stands. The *S. odoratum* juveniles were all in just one plot, so finding them only in an alien stand may have been a sampling artifact. Regardless of where *S. odoratus* is recruiting, its population structure appears very unstable. *Alyxia oliviformis* was recruiting in much lower numbers than it was in native stands. In alien stands, the numbers of *A. oliviformis* juveniles were also lower than the numbers of adults (Table 2), indicating an unstable population structure in even this comparatively thriving species. This change for the worse in the numbers and ratios of *A. oliviformis* individuals shows that alien plant species are having a detrimental effect on native recruitment.

There were 12 native species which were essentially not recruiting at all (Table 3). Given that many of these species occurred in the plots only a few times, it is difficult to make any definitive conclusion regarding the stability of these populations. This low sampling could be due to sampling error, to advanced decline in the populations, or to both. Several other species do have relatively high numbers of adults and were thus of concern; *Nestegis sandwicensis* and *Hedyotis terminalis* in particular appear to be in decline. According to the resource managers, *H. terminalis* does produce ripe fruit, and its seeds do germinate in the greenhouse (K. Kawelo & J. Rohrer, pers. comm.). This would indicate that establishment is inhibited at the juvenile stage, possibly by competition, predation or both; more research on establishment is needed. *N. sandwicensis* does flower, but the managers have never observed mature fruit (K. Kawelo & J. Rohrer, pers.com.). The trees may be suffering from lack of pollinators or from seed predation. Similarly, the managers have been unable to collect undamaged/viable seed from *P. odoratum* (K. Kawelo & J. Rohrer, pers.com.). They have found evidence of a seed predator which has not been identified.

Conclusions

Native and alien stands are in fact less discrete than they first appeared. The native patches are being invaded, alien species are recruiting substantially more than native species, and even if alien species do not become dominant, it is almost certain that native diversity will decrease. Given that this is a managed reserve, which has been fenced and weeded, this does not bode well for the future. Ungulate exclusion has been important, but alien plants are now established and continue to reproduce. Trapping rats and fencing do not prevent herbivory and predation by invertebrates. Further investigation into the nature and impacts of these organisms is necessary. Continued outplanting to augment population numbers may help; our findings suggest that *H. terminalis* could be a good candidate. The emphasis of future efforts should be on clarifying the threats to establishment and survival. If these are not eliminated. outplanting may simply fail. The managers are doing good work, but their work, and ours, is by no means all pau.

Acknowledgements:

Many thanks to Kapua Kawelo, Joby Rorher, and the rest of the field staff at the Natural Resources office for all their help. Thanks also to our volunteers Erin Goergen, Maile Gresham and Mark Stoutemeyer, and to Andy Taylor, Curt Daehler, and Cliff Morden for statistical and logistical assistance. This research was conducted as a course project for *Ecology, Evolution and Conservation Biology*

in Hawaii in the Departments of Botany and Zoology, UH Mānoa

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Growing Native
A Regular Feature on Native Plant Horticulture

A Highly Effective Method for Germinating *aulu/lonomea* (*Sapindus oahuensis*)

Bruce P. Koebele
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This column is based on contributions from members. Anyone wishing to share information about growing native plants can send it to the Society, or contact any of the members of the Native Plant Committee. There are no format or style restrictions; anything from one sentence to several paragraphs is appropriate. We do recommend listing both scientific and common names of plants, and giving an address and telephone number at which readers can contact you for more information. In this issue, Dr. Bruce Koebele reports his experiences propagating several dryland species.

Aulu or lonomea (as it is known on Kaua'i) has the potential to become an important tree for dry forest restoration projects in Hawai'i. It grows quickly, has few serious pests, and produces both a dense shade and thick leaf litter that inhibits the growth of most understory alien plants (including grasses). Unfortunately, germination of whole or scarified seeds can take from one to six months with variable success. (The seeds are prone to rot.) In a recent Hawaiian Botanical Society Newsletter (Volume 37 Number 2) article compiled by The Nature Conservancy of Hawai'i a new method for the rapid germination of aulu was very briefly outlined. This article elaborates on this method.

Collect only mature fruit, either from the tree or the ground beneath. Remove the seed from the fruit and inspect it carefully for insect damage. Discard any seed that floats in tapwater; it is usually inviable. Scar the outer coat (with garden clippers or a knife) and place the seed in clean, moist vermiculite for one to two weeks. Alternatively, you can soak the scarred seed in a shallow pan of water, changing the water daily. This pretreatment softens the dark outer seed coat so you can remove it easily by hand or with a small knife. After removing the outer seed coat, carefully peel away the inner, thin, papery brown seed coat from the cream colored embryo. At one point the inner seed coat wraps under the embryonic root. Exercise special care here or you will break the root while removing the seed coat. If you do, discard the embryo and try again with a new seed. Plant the embryo immediately, one to two centimeters deep in clean potting soil. If you intend to plant the embryo in a field setting, transport it in a moist paper towel until you reach the site.

In new artificial soil, germination is nearly 100%, with the shoot breaking through the soil surface in about one week. Seedling survival is normally excellent and growth is rapid. Under nursery conditions aulu will grow approximately one meter per year. In one experimental field trial, excised embryos planted directly into the native soil and watered (two liters per embryo) resulted in approximately 30% germination .

Kuli'ou'ou Trail Native Plant List

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This article is the first of a series in a project to publish native plant lists for major O'ahu trails in this journal over the next year or two for the purposes of botanical education and historical record. This project is being coordinated by the author with the aid of botanists on the O'ahu Trails Committee (see ACKNOWLEDGEMENTS) who will gather earlier lists of plants on key trails and compile updated lists in a format broadly similar to the one below. We encourage those who have interests in this subject, or have expertise on particular trails, to become involved by contacting the author, the Hawaiian Botanical Society, or members of the O'ahu Trails Committee.

Survey Dates: June 10, 1998; July 3, 1998; August 21, 1998.

Reason for Trail Selection: Kuli'ou'ou trail is the last major trail going east down the Koíolau Crest (Diamond Head Side) toward Makapu'u Point which has significant endemic forest.

Location Reference: and following it up to Kalaau Place. State trail sign is at end of Kalaau Place. Begin on the Kuli'ou'ou Valley trail until state trail sign shows Oahu Sectional Map #18 and 24; USGS Map: Koko Head Quadrangle.

Access: State trail with unimpeded access. Trailhead found by taking Kuli'ou'ou Road mauka off Kalanianaole Hwy intersection with Kuli'ou'ou Ridge trail, which heads uphill east (to the right).

Elevations: 280-2028 ft.

Native Plants: Lower and Middle Trail (Dryland Forest Zone):

Canthium odoratum (Alahe'e)
Dodonaea viscosa ('A'ali'i)
Doryopteris decipiens ('iwa'iwa)
Erythrina sandwicensis (wiliwili)
Lepisorus thunbergianus (pakahakaha)
Pandanus tectorius (hala)
Psilotum nudum (moa)
Odontosoria chinensis (pala'a)
Osteomeles anthyllidifolia ('ulei)
Peperomia leptostachya ('ala'ala wai nui)
Sida fallax ('ilima)

Side Trails Taken: Right ridge side trail just before trail shelter. Native plants seen on side trail: *Sida fallax* ('ilima). Reportedly decreased in numbers since seen 10/95.

Other Notes:

A.*Santalum ellipticum* (dryland sandalwood) looked for, but not seen.

B. *Erythrina sandwicensis* appears to have been planted recently.

C. Significant introduced plants: *Abutilon incanum*, *Acacia confusa*, *Adiantum hispidulum* (fern), *Araucaria columnaris* (Cook Pine), *Ardisia elliptica*, *Arundina graminifolia* (bamboo orchid), *Blechnum occidentale* (fern), *Casuarina equisetifolia* (ironwood), *Clusia rosea* (autograph tree), *Cordyline fruticosa* (ti), *Eucalyptus robusta* (swamp mahogany), *Ficus* sp., *Grevillea robusta* (silk oak), *Haematoxylum*

campechianum (bloodwood), *Kalanchoe pinnata*, *Leucaena leucocephala* (koa haole), *Macadamia integrifolia*, *Melaleuca quinquenervia*, *Mimulus* sp. (monkey face plant), *Morinda citrifolia* (noni), *Oplismenus hirtellus* (basket grass), *Passiflora suberosa* (passion flower), *Pellaea viridis* (fern), *Phlebodium aureum* (hare's foot fern), *Phymatosorus grossus* (laua'e fern), *Pimenta dioica* (allspice), *Psidium cattleianum* (strawberry guava), *Schinus terebinthifolius* (christmas berry), *Stachytarpheta jamaicensis* (jamaican vervain), *Stapelia nobilis* (carrion flower), and fan palm (planted, definitely not loulu).

D. *Haematoxylum* (Bloodwood), was introduced on Oahu and the Big Island from Central America.

E. *Dodonea* (A'ali'i) is rare on this trail.

F. Milo (*Thespesia populnea*) appears to have been planted recently on this trail.

G. The upper reaches of this zone are notable for Forestry plantings of Cook Pines (*Araucaria cooki*), and *Ficus* sp. A few lama trees (*Diospyros sandwicensis*) are observed at the very upper edge of this zone, bordering the native rain forest zone which was apparently left intact. For absence of native mesic forest zone, see Note A under Rain Forest Zone below.

Native Plants: Upper Trail

(Rain Forest Zone--1480 ft to Crest):

Alyxia oliviformis (maile)
Asplenium nidus ('ekaha; bird's nest fern)
Bidens sandwicensis (ko'oko'olau)
Bobea elatior ('ahakea lau nui)
Chamaesyce multiformis ('akoko)
Cibotium chamissoi (hapu'u)
Dianella sandwicensis ('uki'uki)
Dicranopteris linearis (uluhe)
Diospyros sandwicensis (lama)
Elaphoglossum fauriei (fern)
Freycinetia arborea ('ie 'ie)
Frullania sp. (liverwort)
Hedyotis terminalis (manono)
Huperzia phyllantha (wawae'iole)
Ilex anomala (kawa'u)
Lepisorus thunbergianus (pakahakaha)
Machaerina mariscoides ('uki)
Metrosideros polymorpha ('ohi'a)
Myrsine lessertiana (kolea)
Odontosoria chinensis (pala'a)
Peperomia tetraphylla ('ala 'ala wai nui)
Perrottetia sandwicensis (olomea)
Pipturus albidus (mamaki)
Pittosporum glabrum (ho'awa)
Psilotum nudum (moa)
Pteridium decompositum (kilau)
Psychotria kaduana (kopiko)
Sadleria cyatheoides ('ama'u)
Selaginella arbuscula (lepelepeamoa; club moss)
Tetraplasandra oahuensis ('ohe).
Wikstroemia oahuensis ('akia)

Side Trails Taken: None

Other Notes:

A. Kuli'ou'ou trail has no mesic native forest zone. This native vegetation zone was apparently either missing or entirely wiped out when extensive forestry plantings covered (and still cover) what would have been the mesic zone. Lama (*Diospyros sandwicensis*) is observed at the end of the planted Cook pine zone, just below the beginning of the rain forest zone. This could be a remnant indicating one native species the mesic zone may have
included.

B. Koa looked for, not seen; lobelioids looked for, not seen.

C. Significant introduced plants: *Ageratina ripara* (maui pamakani), *Aleurites moluccana* (kukui), *Araucaria columnaris* (cook Pine), *Ardisia* sp., *Blechnum occidentale* (fern), *Conyza bonariensis* (hairy horseweed), *Christella parasitica* (fern), *Clidemia hirta* (koster's curse), *Cordyline fruticosa* (ti), *Desmodium* sp., *Grevillea robusta*, *Lantana camara*, *Macaranga mappa*, *Melinus*

minutiflora (molasses grass), *Musa* sp., *Nephrolepis multiflora* (sword fern), *Paspalum conjugatum* (hilo grass), *Passiflora edulis* (lilikoi vine), *Phymatosorus grossus* (fern), *Psidium cattleianum* (strawberry guava), *Rubus rosifolius* (thimbleberry), *Schefflera* sp., *Schinus terebinthifolius* (christmas Berry), *Spathoglottis plicata* (malayan ground orchid), *Trema orientalis*, *Zingiber zerumbet* (soap ginger), imperial palms.

D. Botanical list from 7 May 95 (Leilani Pyle) indicate *Melicope* sp.(alani) from this zone, but this was not found on any 1998 survey dates.

E. *Frullania* sp. liverwort is seen on rain forest area 'ohi'a trees.

F. *Tetraplasandra* sp. (probably *T. oahuensis*. Has compound umbellate yellow flowers.

Native Plants: Ridge Crest

(Cloud Forest Zone--1980 to 2028ft):

Bidens sandwicensis (ko'oko'olau)
Chamaesyce multiformis ('akoko)
Eleaocarpus bifidus (kalia)
Hedyotis acuminata (Au)
Ilex anomala (kawa'u)
Lycopodiella cernua (wawae'iole)
Metrosideros polymorpha ('ohi'a)
Peperomia tetraphylla ('ala'ala wai nui)
Phyllanthus distichus (pamakani)
Pipturus albidus (mamaki)
Sadleria cyatheoides ('ama'u)
Smilax melastomifolia (hoi kuahiwi)
Odontosoria chinensis (pala'a)
Wikstroemia oahuensis ('akia)

Side Trails Taken: East Crest Trail (to cliff bog). Native plants seen on side trail: *Pipturus albidus*(mamaki), *Ilex anomala* (holly), *Metrosideros polymorpha*, *Metrosideros tremuloides*, *Sadleria cyatheoides*, *Wikstroemia oahuensis*, *Smilax melastomifolia*, *Psychotria kaduana* (kopiko), *Odontosoria chinensis*, *Cocculus orbiculatus* (huehue), *Alyxia olivaeformis* (Maile), *Freycinetia arborea* ('ie'ie), *Machaerina mariscoides* ('uki), *Selaginella arbuscula* (lepelepeamoa), *Bidens sandwicensis* (Ko'oko'olau), *Plectranthus parviflorus*(mint).

Other Notes:

A. Cliff bog on right side trail ca. 200 ft. Last bog of its type from East Oahu to Mokapuíu Point.

B. Many signs of early Hawaiian habitation in Kaalakei Valley on right side of trail near summit.

C. Lobelias looked for, not seen.

D. Crest is infiltrated with significant numbers of introduced plants, including *Ardisia* sp., *Clidemia hirta*, *Christella parasitica* (fern), *Stachytarpheta jamaicensis* (vervain), *Passiflora* sp., and *Cuphea* (cigar flower).

ACKNOWLEDGMENTS

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Hawaiian Botanical Society Awardees at the Science and Engineering Fair

The 41st Hawaii State Science and Engineering Fair was held 30 March to 3 April, 1998 at the Neil Blaisdale Exhibition Center. The Hawaiian Botanical Society presented awards to the following individuals:

Senior Division Research Project
First Place—Janelle S. Ishida, Moloka'i High School: "Use of Salt Water to Control Non-Native Plants on a Coastal Strand Community."

Second Place—Karen Horiuchi, Waiakea High School: "*In Vitro* Propagation of Palapalai (*Microlepia setosa* [*strigosa*])."

Junior Division Research Project
First Place—Su Que Leong, Kawananakoa Intermediate: "Allelochemical Effects on the Germination of *Miconia calvescens* Seeds."

Second Place—Kade Hashimoto, Kapa'a Intermediate: "The Allelopathic Properties of *Casuarina equisetifolia* as a Possible Pre-Emergent Weed Control."

All four students received a signed copy of Dr. Isabella Abbott's book *La'au Hawai'i.* In addition, each first place winner received $50.00, and each second place winner received $25.00.

If anyone is interested in becoming a Science Fair judge for the society, please contact the Botanical Society Science Fair Committee, c/o Karen Shigematsu at 988-3177

Botanical Trail Key for Hawaiian Plants

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The purpose of this key is to aid the student of Hawaiian plants in basic identification of most endemic Hawaiian trees and shrubs in the native or mostly native forest areas of the islands. To use the key in the most effective fashion, the student or hiker should be aware of which trails are known to have native plants on them, or which sections of trails (for example, middle and upper elevation sections of many trails) will likely have native plants. It assumes a basic knowledge of botany only, and uses some common descriptive terms when higher-level botanical terms may not be well-known. Its goal is to enable the interested amateur or student to reach to the genus level of identification of the plant, from which point they may consult the manuals (such as the two volume manual...), and other authorities (such as Lamb's Trees and Shrubs...) to research more species-level identification if they wish to pursue this. The key focuses mostly endemic trees and shrubs. It does include a few indigenous and Polynesian-brought plants. It does not include a few extremely rare species, types found only on one island, or the lobelias. It lists characteristics which are most likely to stand out in identification, especially in contrast to other similar plants.

A. Leaves

1. *Shiny:* Plumeria relatives (Hao? Holei), *Charpentiera* (Papala), *Pisonia* (Papala Kepau), Olapa and Lapalapa (*Cheirodendron*), Ae (*Zanthoxylum*), Anapanapa (*Colubrina*), Ala'a (*Pouteria*), Milo (*Thespesia*), Kamani (*Calphyllum*), Maua (*Xylosma*), Olive (Osmanthus), Kamakahala (*Labordia*), Alahe'e (*Canthium*). Pilo (*Coprosma*), Manono (*Gouldia*), Kopiko (*Psychotria mariniana*, with holes under leaf at midrib), *Hibiscus*
2. *Dull:* (Purple Naupaka-*Scaevola*), (Lowland sandalwood—*Santalum ellipticum*), Mamaki (*Pipturus*), Olona (*Touchardia*), Hame (*Antidesma* II), Mahoe (Soapberry), Lama I & II (Diospyros), *Cyrtandra* (Haiwale, *Gesneria*), pale green (Ahakea, *Bobea*)
3. *Venation:* red (Olomea-*Perrottetia*), Olona (Touchardia), some Mamaki (*Pipturus*), and *Bobea* (Ahakea); very prominent: *Ilex* (chaotic, Holly), Anapanapa (*Colubrina*, white, drooping) Olive (*Osmanthus*)
4. *Large:* (*Pisonia*-Papala Kepau, shiny), (Kanawao--*Broussaisia*), Mahoe (Soapberry), Kolea I; Olive (*Osmanthus*), Kou (*Cordia*), *Cyrtandra* (Haiwale), Lama II, PiloII, Manono (*Gouldia*)
5. *Small:* (Upland Sandalwood--*Freycinetia*), Akia(*Wikstroemia*), Kolea II (*Myrsine*), Kolomona (*Senna*), Maile (*Alyxia*), yellow naupaka (*Scaevola gaudichaudii*), Alahe'e (*Canthium*), Pilo II
6. *Tomentose (fuzzy):* Hoawa (*Pittosporum confertifolium*), Hame (on back *Antidesma* 11), Ala'a (brown,underside), Purple Naupaka (*Scaevola*), Kului (*Nototrichum* shrub), *Bonamea* (vine)
7. *Sharp ended:* (all upland Naupaka), (*Pisonia*), (*Rauvolfia*), Mamaki (*Pipturus*), Olona (*Touchardia*), Upland Sandalwood (*Santalum freycinetianum*), Hala & ieie (Pandanus, freycinetia), Ae (*Zanthoxylum*), Kukui (*Aleurites*), Kamakahala (*Labordia*), Naio (*Myoporum*), *Bobea* (Alakea) *Dubautia* (Naenae--silversword rels)
8. *New leaves colored:* Ohia, Lama (pink), Cinnamon (pink) ,*Olomea* (red), Hame (peach), Ala'a (copper), *Xylosma* (Maua-red), Kolea I(red, *Myrsine*)
9. *Non-green leaves:* silver: Kului (*Nototrichum*), Hinihina (*Artemesia* sp.), *Xylosma* (red-tinted)
10. *Leaves ragged/wavery:* A'ali'i, *Cyanea angustifolia* (HaHa), Kalia (*Eleaocarpus*), Olive (crinkled-*Osmanthus*), Kou (*Cordia*)
11. *Leaves wider than long:* Lapalapa (*Cheirodendron*), Wiliwili (*Erythrina*), Milo (Thespesia, heart-shaped, also Hau (*Hibiscus teliaceus*), and *Hibiscus arnottianus* (Oahu white)

12. *Leaves compound or sawtooth:* Mamane (*Sophora*) tiny leaves, in 6-10 pairs, Ohe Ohe (Tetraplasandra oahuensis), Neneleau (*Rhus*, sumac), Kolomona (*Senna* lXl/2", 3-5 prs)
13. *Leaves quavering:* Kalia (*Eleaocarpus*), Lapalapa (*Cheirodendron*), Olapa (*Cheirodendron*)
14. *Leaves oval/elliptical:* Ala'a (Pouteria), Olapa (*Cheirodendron*), Kamani (*Calophyllum*), Maua (*Xylosma*)
15. *Leaves thick leatherv:* Kamakahala (*Labordia*), *Hydrangea* (Kawanao), Manono (*Gouldia*) *Dubautia* (Kupaoa--Silversword rel.), Pilo (*Coprosma*), Kopiko (*Psychotria*)
16. Leaves w*horled: Ochrosia* (3-4) & *Rauvolfia* (5), *Pittorporum terminaloides* & *P. confertifolium, Dubautia* (crowded toward end. Silversword rel.)
17. *Leaves rounded at end: Charpentiera* (Papala), *Pittosporum confertifolium* & *P. terminaloides, Hibiscus*, Hau, Manono (*Gouldia*), Kopiko (*Psychotria*), Lowland Sandalwood (*Santalum ellipticum*), Alani (*Pelea*)
18. *Newleaves "kissing":* kopiko (*Psychotria*), some *Hedyotis*

B. Petioles/midrib:

1. *Absent or very short:* Mamaki and Olona (*Touchardia*), *Rauvolfia* (Hao), Manono (*Gouldia*)
2. *Long or prominent: Charpentiera* (Papala), Koamature (*Acacia*), Hame I (prominent green midrib, red petiole), Mahoe (Soapberry-prominent mid, short petioles), A'ali'i (*Dodonaea*), Kalia (*Eleaocarpus*--mid green, prom., yellow petioles), Ala'a (long yellow pet., pouteria), *Xylosma* (Maua, yellow mid), Kou (Cordia, prom. midrib), Naio (*Myoporum*), Manono (*Gouldia*)
3. *Colored red:* Olomea (*Perrottetia*), *Charpentiera* (Papala), Hame (*Antidesma*), Kauila (*Colubrina*); yellow (Hao, *Rauvolfia*), (*Ochrosia*, Holei)

C. Flowers:

1. *Ends of stems:* Lowland Sandalwood (*Santallum ellipticum*), *Pisonia* (Papala Kepau), Ae (*Zanthoxylum*), Neneleau (sumac, *Rhus*), Kawila (*Colubrina*), Kalia (*Eleaocarpus*),
2. *On stems:* (Kolea lau nui or Kolea lau li'i--*Myrsine*), Mamaki (*Pipturus*), Alani (*Pelea*), Ilex (Holly, Kawau), Manono (*Gouldia*), *Pittosporum confertifolium* (Hoawa), *Pouteria* (Ala'a)
3. *Colors:* White: Kukui, Bobea (Ahakea), *Ochrosia*, *Rauvolfia*; Green: Mamaki, Yellow: Lowland Sandalwood (*S. ellipticum*), Alani (*Pelea*), Mamane (*Sophora*), Kauila (Colubrina); Orange: ieie, Kou (*Cordia*). Yellow—Kolomona (*Senna*), Mamane. Red: Charpentiera-Papala (tiny red strings), wiliwili (also orange or white), Cream-colored: Alani (*Pelea*)
4. *Particular shape:* Propellor-*Ochrosia*(Holei) *Rauvolfia's* are small and in bunches of 20+; star--Kauila (*Colubrina*), candle-like--*Tetraplasandra oahuensis* (Ohe ohe); white trumpet-shaped: *Plumbago* and manono (*Gouldia*); cream-colored small tulips—Alani (*Pelea*)

D. Fruits

As cherries: (Hame I, *Antidesma*), O'hia Ha; Purple: (*Ilex*, Holly, Kawau), Olive (*Osmanthus*, Olopua); red: (sumac, Neneleau); Hilo Holly; round on long stem-Kamani (*Calophyllum*); black berry (*Bobea*); Pecans with sharp ends (*Ochrosia*, Holei, vs. small, black *Rauvolfia*--Hao); *Sapinda* (Soapberry--large brown *Ochrosia* -like seed); large oval green: *Bonamea* vine.

E. Trunk/Stems

White to light yellow or orange: Wiliwili (*Erythrina*), corrugated—mamane; smooth (Kolomana); Vertical striated: Hame (*Antidesma*)

F. Shrubby

A'ali'i (*Dodonea*)--often shrubby, but can be a tree; Pukiawe (Styphelia), Mamane (*Sophora*), Akoko (Chamaesyce), Neneleau (Sumac, *Rhus*), Anapanapa (*Colubrina asiatica*), Akia (*Wikstroemia*), Kolomona (*Senna*), *Dubautia* (Silversword rel.), *Hydrangea* (Broussaisia) Naio (*Myoporum*), *Hedyotis terminalis* and H. littoralis, Alahe'e (*Canthium*), Pilo (*Coprosma*); Manono (*Gouldia*), Hao (*Hibiscus*), Kulu (*Nototrichum*)

G. Viney

Smilax (Hoi); Maile (*Alyxia*), *Plumbago* (shiny leaves, white trumpet flowers), *Bonamea*

H.. Milky sap

Akoko (*Chamaesyce*)

Minutes of the Hawaiian Botanical Society

May Meeting

• The May 5, 1998 meeting of the Hawaiian Botanical Society was called to order by Mindy Wilkinson, President.

• The minutes were approved as read.

• Two guests were introduced.

• **Treasurer's Report**. Ron Fenstemacher read the treasurer's report. The current account balance was $5284.19.

• **Membership Report.** Gerald Toyomura reported that there were four new members.

• **Old Business**

  • The Earth Justice Defense Fund relayed, through James Kwon, that the U.S. Fish and Wildlife Service had agreed to designate plants for which it was prudent to have critical habitat named by the year 2004.

  • The Calendar Committee announced that it would cost approximately $800 for 500 copies of a 1 sheet with pictures calendar.

  • A thank you note was received from the science fair winner.

• **New Business**

  • The Dept. of Land and Natural Resources, through Randy Kennedy, asked to have a Botanical Society representative to the Kaena Point Meetings to be held on the 1st Wednesday of every month in Haleiwa. The meetings would concern proposed uses for the Kaena Point Natural Area Reserve.

• **Plant of the Month** was pili grass, Heteropogon contortus, and was presented by Debbie Carino of the University of Hawai'i Department of Botany.

• **Guest Speaker.** The speaker for May was Puanani Wong of the University of Hawai'i Department of Botany. Her talk was entitled "How to Make the Story of Hawaii's Natural Heritage Positive and Fun."

September Meeting

• The September 14th, 1998 meeting of the Hawaiian Botanical Society was called to order by Mindy Wilkinson, President.

• Four guests were introduced.

• The minutes from the May 5th, 1998 meeting of the Botanical Society were read by Leilani Durand and approved.

• **Treasurer's Report.** Ron Fenstemacher read the treasurer's report. As of last May, the Botanical Society had $5287.91 in its account. The outgo of funds over the summer totaled $4993.40, and the income totaled $3605.72. Our current balance is $3900.23.

• **Membership Report.** Gerald Toyomura announced there were a total of 226 members, with 16 renewals and 8 new members. The new members were announced.

• Alvin Yoshinaga discussed the appointment of Honorary Members to the Botanical Society. A motion was made to nominate Jon Obata to be an honorary member, and the motion was approved.

• **Committee Reports**

  The Native Plant Committee will start a regular column in the Botanical Society newsletter that will present bits of wisdom

about growing native plants. Contributions are welcome.

- **Old Business:**
  - A letter from the Science Fair winner Sue Lyong was read.

- **New Business**
  - An anonymous request to send a letter to Walmart on the Big Island to ask them to stop selling the Australian tree fern was received. A draft will be presented for the membership to approve.

  - The Oahu fountaingrass Working group draft letter was passed around for the membership to review. Comments were requested.

  - Dave Orr from the Waimea Arboretum announced that the Botanical Garden is threatened. The owners have threatened to eliminate the Botanical garden, and there are currently only three people on the staff so they are trying to distribute plants to other collections.

  - Alvin Yoshinaga announced a possible trip to Koke'e or Hakalau. Members should see Alvin if they are interested.

- **Plant of the Month** talk was Akala, *Rubus hawaiiensis* and other *Rubus* in Hawai'i by Cliff Morden, UH Department of Botany.

- **Guest Speaker.** Mike Clearwater, of Hawaii Agricultural Research Center was the featured speaker. His talk was entitled "Forestry research in the lowland dipterocarp forests of Indonesian Borneo."

October Meetings

- The October 5th, 1998 meeting of the Hawaiian Botanical Society was called to order by Mindy Wilkinson, President.

- One guest was introduced.

- The minutes from the September 14th, 1998 meeting were read by Leilani Durand and approved.

- **Treasurer's Report.** Ron Fenstemacher read the treasurer's report, stating that the ending balance in our account was $3738.08, was read and approved. Also announced was that in her will, Bea Krauss left 5% of her estate to the Botanical Society. It was requested that someone volunteer to audit the books.

- **Membership Report.** Gerald Toyomura gave the membership report and stated that there were 4 new members and 4 renewals, bringing current membership to 233 members.

- **Committee Reports**
  - A nominating committee needs to be created to determine nominees for next year's Botanical Society officers.

- **Old Business**
  - The letter to WalMart requesting that they stop selling the Australian tree fern is still being written.

- **New Business**
  - An update on the status of the Sierra Club Legal Defense Fund (Earth Justice Legal Defense Fund) was given.

- **Plant of the Month** was given by Tim Motley of the New York Botanical Garden. His talk was entitled "A new species of *manono* (*Hedyotis*) for the Kohala Coast."

- **Guest Speaker.** The speaker for October was Betsy Gagne of the Dept. of Land and Natural Resources, who led a discussion on "Implementing New Rules for Private Propagation of Endangered Hawaiian Plants."

November Meeting

• The November 2, 1998 meeting of the Hawaiian Botanical Society was called to order by Mindy Wilkinson, President.

• Five guests were introduced.

• The minutes from the October 5th meeting were read by Leilani Durand and approved.

• **Treasurer's Report**. Ron Fenstemacher reported that the ending balance in our account was $4225.00. The report was read and approved.

• **Membership Report.** Gerald Toyomura reported that there were 245 current members.

• **Committee reports**
  • The Conservation Committee announced that members are still needed.
  • The Nominating Committee announced that nominees for the upcoming Botanical Society elections were still being sought.

• **Old Business**
A letter regarding the availability of the Australian tree fern for sale on the Big Island, was still in the process of being drafted.

• **New Business**
  • The Botanical Society's 75th anniversary is coming up in May of 1999, and suggestions regarding how to celebrate this event were welcome.

• **Plant of the Month** was "*Metrosideros* - a Hawaiian Enigma" given by Susan Grose of the UH Manoa Botany Department .

• **Guest Speaker.** The guest speaker was Sheila Conant of the UH Zoology Department whose presentation was entitled "Natural History and Conservation in the Northwest Hawaiian Islands."

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EWSLETTER OF THE HAWAIIAN BOTANICAL SOCIETY
/O DEPARTMENT OF BOTANY
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